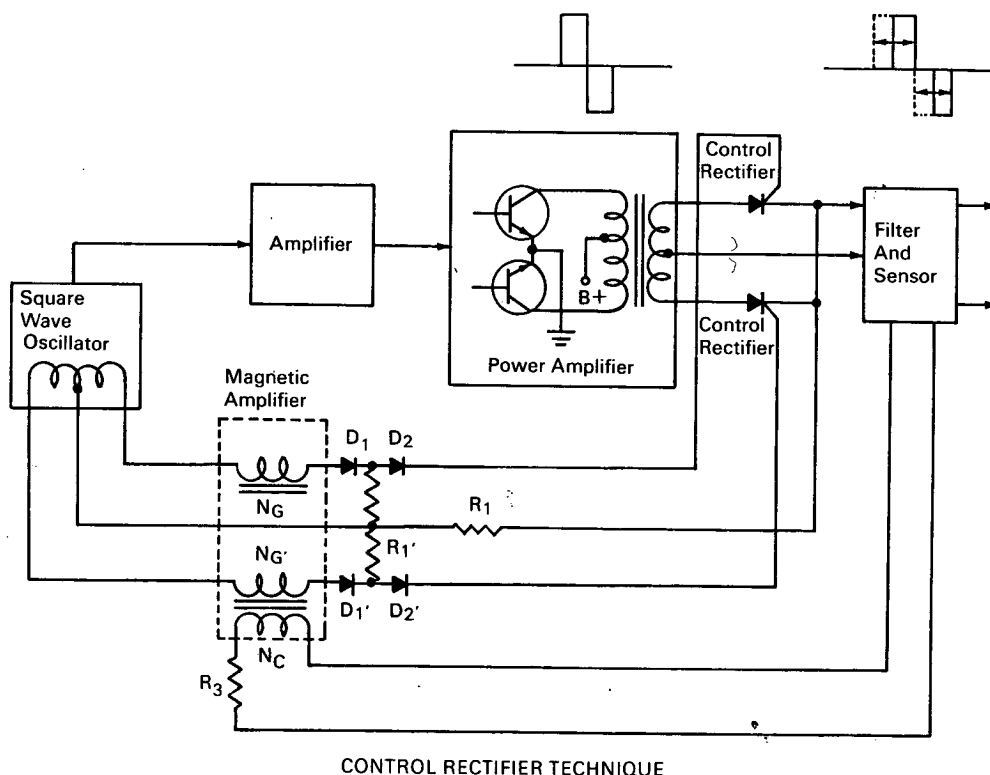


NASA TECH BRIEF



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High Power DC/DC and DC/AC Electrical Power Conversion Techniques Developed



Magnetic modulators or amplifiers have previously been used to drive power transistors directly. The magnetic modulator alternately controls the on-time of each transistor in such a manner that a pulse duration modulated square wave is used for regulation. This approach has been used successfully in many applications; however, where a large amount of power is required, the magnetic modulator's weight and volume could become excessive. If magnetic amplifiers

are used at low levels and power amplification necessary to drive the power stages is obtained by the use of additional transistors, the interstage and output transformers must be oversized, if distortion of positive and negative pulses is to be eliminated.

The solution to this problem is to use very small magnetic amplifiers and pass square waves through all transformers. The simplest way to do this and provide regulation is to vary the pulse width on the

(continued overleaf)

secondary of the output power transformers. Two techniques of accomplishing this follow.

Control Rectifier Technique. One very simple method of providing pulse duration modulation on the secondary of power transformers is by using a small, two-core magnetic amplifier or modulator to switch control rectifiers in the secondary legs of the output transformer. On each alternate half cycle of the supply frequency, the leading edge of the magnetic amplifier output switches the associated control rectifier on and it remains on for the remainder of the one-half cycle. Thus, by varying the leading edge of the pulses feeding into the control rectifiers, the output voltage is variable and, with proper feedback to the control winding of the magnetic amplifier, regulation can be accomplished.

When connected as shown, the ac output from the power stage is rectified by the control rectifiers, and a regulated dc is obtained when a filter and sensing circuit are placed in the circuit.

Diodes D_1 and D_1' are associated with the magnetic amplifier for self-saturation purposes. Diodes D_2 and D_2' prevent the magnetic amplifier magnetizing current from triggering the control rectifiers at the beginning of each half cycle. Normally, the magnetic amplifier would be designed for approximately a 5-volt, 25-ma output. This provides power for triggering the control rectifier for most applications. The circuit parameters are not critical and a maximum flux density value can be used for the design of all transformers. Since the magnetic amplifier provides isolation between the control winding, N_c , and the gate windings N_g and N_g' , the output voltage can be at a high potential and a conventional bridge circuit can be utilized for sensing.

The Phase-Shift Technique. A phase-shift technique incorporating a magnetic amplifier or modulator is shown. The magnetic section is a conventional push-pull low level magnetic amplifier with a variable pulse width output. When power is applied, the leading edge of the signal from the magnetic amplifier switches on transistor Tr_1 ; transistor Tr_2 remains off since it does not have a positive signal on its base. The collector of transistor Tr_2 will be at a high positive potential, a

portion of which will be applied to the base of transistor Tr_1 through the feedback circuit R_f and Z_2 , holding it on until transistor Tr_2 is switched on during the next half cycle. During the next half cycle, transistor Tr_2 is switched on by the leading edge of the magnetic amplifier and the sequence repeats. From this push-pull network with positive feedback, a square wave is obtained and its phase, with reference to the signal driving the magnetic amplifier, is variable from 0° to approximately 170° . The amount of phase shift can be easily controlled by varying the firing point of the magnetic amplifier which in turn is controlled by the dc signal applied to the control winding N_c . Zener diodes Z_1 and Z_2 are inserted into the feedback line to allow positive feedback into the base of the "on" transistor for the one-half cycle required; and to insure that the "off" transistor is not turned on by the small positive potential on the collector of the "on" transistor because of its saturation resistance. This is accomplished by selecting Zener diodes that have a breakdown voltage greater than the collector to emitter voltage of an "on" transistor. D_1 and D_1' allow self-saturation of the magnetic cores whereas diodes D_2 and D_2' block the magnetizing current of the magnetic amplifier from the bases of the transistors.

Notes:

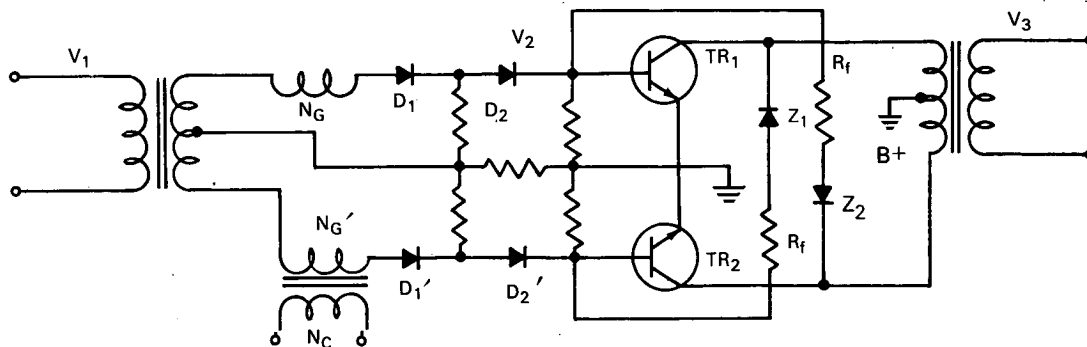
1. The phase shift technique described has been successfully utilized in a power supply to test an ion engine requiring various voltages and currents for operation. A total of 1500 watts was required at a 2500 volt potential, with a single 800 watt unit delivering most of the power. The ion engine (Hg ions) was tested in space.
2. Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B67-10390

Patent status:

No patent action is completed by NASA.

Source: G. Berryman and W. T. White
(MFS-13227)



PHASE SHIFT TECHNIQUE